UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

COLLEGE OF ENGINEERING
DEPARTMENT OF NUCLEAR ENGINEERING
PER F. PETERSON
TELEPHONE: (510) 643-7749
FAX: (510) 643-9685
EMAIL: peterson@nuc.berkeley.edu

BERKELEY, CALIFORNIA 94720-1730

550508

September 5, 2001

RECEIVED

SEP 14 2001

Carol Hanlon
S&ER Products Manager
U. S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 30307 M/S 025
North Las Vegas, NV 89036-0707

Re: Comments on Yucca Mountain Preliminary Site Suitability Decision

Dear Ms. Hanlon,

I am writing to provide comments and recommendations based on my review of the Yucca Mountain Preliminary Site Suitability Decision report, DOE RW-0540. My review focuses primarily on the engineered barrier system. The current engineered barrier system applies the safety principles that have been widely used for design and licensing of aircraft and nuclear reactors. Results from the current total-system performance model (TSPM) suggest that the engineered-barrier system can meet the required licensing criteria by large margins.

Following well-established safety design principles, multiple, independent and diverse barriers have been used in the Yucca Mountain (YM) engineered-barrier system. With multiple barriers the failure of any individual barrier, even from unanticipated mechanisms, does not degrade overall system performance. This design approach is robust due to its inherent conservatism, which can accommodate the introduction of new information during the final design process and still maintain high system performance. This provides the basis for my primary conclusion, that the current repository design is likely to be successful in meeting the applicable radiation protection standards established by the EPA and NRC, if the site is recommended to the President and if Congress directs the DOE to prepare and submit a construction license application to the NRC.

I also provide below a comparison of the YM site with the different geologic media being considered by various international repository research programs. The United States, due to its large and diverse array of geologic settings, had the unique opportunity to identify a potential repository site that is located above the water table in unsaturated hard-rock media. International repository programs which have focused on saturated media have adopted safety design principles similar to those that have now been applied for the YM design. But the YM site has unique flexibility due to the ease with which waste canisters can be moved and rearranged, whereas saturated geologic media require that the waste be embedded and sealed into smaller boreholes. This flexibility is a feature unique to unsaturated geologic media, as at YM, and should be given special weight. Using unsaturated media enhances retrievability and reversibility. Thus the YM site maximizes flexibility for future generations to retrieve and use waste, or to select alternative disposal methods. This minimizes the burden on future generations to manage waste they did not create.

Introduction

My expertise is in the areas of heat and mass transport, the primary processes which govern the performance of geologic repositories. I was educated in Nevada from elementary school through my bachelors degree in Mechanical Engineering (1982) at the University of Nevada at Reno. I hold a masters and doctorate from the University of California at Berkeley. I was a National Science Foundation Presidential Young Investigator from 1990 to 1995, and am currently Professor and Chair of the Department of Nuclear Engineering at U.C. Berkeley. My current research focuses primarily on fusion energy, and I also work in the areas of reactor and radioactive waste tank safety. I have never held research contracts from the Office of Civilian Radioactive Waste Management, so my comments and recommendations are independent from the Department of Energy's (DOE) Suitability Decision work.

The 1987 Congressional amendment of the Nuclear Waste Policy Act directed the DOE to focus its research effort on a single site, at Yucca Mountain in Southern Nevada. Subsequently, U.S. research has been directed at YM, proceeding in parallel with large international efforts that have investigated other potential geologic media for repository siting. If the YM Suitability Decision is negative, this will then require that the United States site a repository in an alternative geologic media, different from the unsaturated tuff found at YM. This is an important consequence; in this letter I add an expert assessment comparing alternative geologic media, so that such a comparison is included as a part of the public record for the decision making process.

The primary types of geologic media that have been investigated for repositories are welded tuff, granite, salt and clay. Tuff and granite are hard rock, and tunnels constructed in these media remain stable for extremely long time periods, allowing reversibility for centuries if future generations so desire. Research, for example as reported in the recent National Academy report "Disposition of High-Level Waste and Spent Fuel" (National Academy Press, 2001), has shown that long-term reversibility is an important, desirable attribute for repository siting and design. Because tuff and granite also have been the most extensively studied geologic media, I focus on comparing them in my discussion.

Comparisons of Alternative Geologic Media

In the United States the granite sites appropriate for repositories are concentrated in the midwestern states, although other granite locations are available including one on the Nevada Test Site near YM.

The geologic medium of a repository performs two primary functions. First it provides physical isolation of the waste and the engineered barriers that immobilize the waste. This protects the waste and engineered barriers from surface events and activities sufficiently long for radionuclides to decay away. Second, the geologic medium delays the transport of any radionuclides that might be released from the waste forms through engineered barriers, reducing any transport to the accessible environment.

Research over the last two decades has shown that the first function of the geologic media, physical isolation, can be achieved with high certainty, so that events such as inadvertent human intrusion can be predicted, bounded, and the potential consequences understood. But, in all geologic settings that have been studied in detail with exploratory tunnels, the natural configuration of the geologic media has been found to be more complex than simple models would predict. Because it is not practical to completely disassemble a mountain to study the configuration and composition of the geologic media, inherent uncertainties are introduced in predicting radionuclide transport through the media. This has caused repository research efforts to focus more toward engineered barriers, to compensate for the uncertainty in predicting the performance of the natural barriers provided by the geologic media.

The geologic media that have been studied for repositories tend to have characteristics which can retard the movement of radionuclides to the accessible environment. For example, YM has natural strata of zeolites underlying the repository horizon, which are known to strongly absorb radionuclides (pgs. 3-29, 3-79). But inherent uncertainty exists for whether all of the ground water that passes through the repository elevation actually contacts the zeolites below. While it is reasonable to expect contact is likely, conservative modeling of the repository-performance requires considering the possibility that the water would bypass the zeolites through fractures, limiting the contact time with zeolite. Indeed, the YM performance model assumes that *no sorption occurs* for the water that flows through fractures in the zeolite region (pg. 3-103) and thus gives little, or no, credit to a natural geochemical feature that is quite likely to actually have a strong, positive effect.

Complexity makes it difficult to characterize transport in the far-field media with certainty. Therefore, repository programs have focused increasing attention on engineering the near-field environment, where conditions can be measured and controlled with confidence. For example the Swedish program, which has performed the most advanced work on repository design for granite media, uses two primary, independent engineered barriers. The design uses a copper canister, which has extremely high durability under the typical granite repository conditions. As a second barrier, a thick layer of highly-impermeable clay surrounds this canister. Either of these barriers alone likely would be sufficient. But with the combination of two barriers (plus the fuel itself, which is quite durable), it becomes highly unlikely that even unanticipated failure mechanisms would cause <u>both</u> barriers to fail.

The YM Project has now adopted the same multiple-barrier design approach as the Swedish repository design. The YM Suitability Decision is based on a design using a highly corrosion-resistant canister material, Alloy 22, that is predicted to have small to negligible corrosion over tens of thousands of years. Independent of the canister material, the design also uses a titanium drip shield—another highly corrosion-resistant material with different corrosion characteristics different from Alloy 22—to prevent any contact of water with the canister. Thus even when the performance analysis assume that one of the barriers fails by an unanticipated, nonmechanistic mechanism, the system still achieves the same overall performance (pg. 3-40).

Because current repository designs are shifting toward the use of engineered barriers to provide the primary isolation of waste, there is little to distinguish YM from other geologic siting options that might have to be explored if the YM Suitability Decision is not positive.

550508

Flexibility, Retrievability, and Reversiblity

The most important characteristic that distinguishes the geologic media at YM from other candidate repository media is its unsaturated state—which allows waste canisters to be placed in open tunnels rather than being embedded into clay or other material in bore holes drilled into sides of the tunnel walls. This is because when siting above the water table the primary goal is to keep water from dripping onto the waste, whereas when siting below the water table the waste must be fully encased by the barriers since it is effectively immersed in water.

Placement of waste in open tunnels greatly increases the flexibility of the waste placement, because it can be easily rearranged or even removed in the future. Because the tunnels at YM are drilled into hard, stable rock, decisions to close the repository can be delayed as long as future generations desire. Conversely, future generations also have the option to permanently close the repository with very minimal effort, particularly compared to the effort that would be required if all of the waste instead were kept in protracted surface storage. The specific, unique characteristics of YM thus give future generations maximum flexibility to recover spent fuel from YM to extract the remaining energy which currently we do not plan to use, to rearrange material to change the repository heat loading, to move the material to a different disposal site, or to simply close the repository.

The Yucca Mountain Preliminary Site Suitability Decision report gives strong evidence that, with the current design of engineered barriers, YM can be licensed to meet the radiation protection standards established by the EPA and NRC. The site is unique among possible geologic media for the flexibility it provides for future generations to make their own decisions about the management of these nuclear wastes, while also minimizing the burdens our generation will place on these future generations. I support a positive site suitability decision.

Sincerely yours,

Per F. Peterson
Professor and Chair
Department of Nuclear Engineering
University of California, Berkeley

cc: Lake H. Barrett, Acting Director, Office of Civilian Radioactive Waste Management